

N92-15875

1991

NASA/ASEE SUMMER FACULTY RESEARCH PROGRAM

MARSHALL SPACE FLIGHT CENTER
THE UNIVERSITY OF ALABAMA IN HUNTSVILLE

EFFECTS OF VEGETATION ON SOIL MOISTURE DISTRIBUTION & FLUX
WITH IMPLICATIONS FOR THE GLOBAL HYDROLOGIC CYCLE

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Date:	July 19, 1991
Contract No.:	The University of Alabama in Huntsville NGT-01-008-021

Abstract

Recent climate modeling experiments have identified the critical need for a better understanding of land surface - atmosphere interactions. An important issues in global climate modeling is to be able to relate land surface and atmospheric processes. In the past this link has been inadequately represented due to the lack of understanding of the interaction between the processes and also due to the large spatial variability of the hydrological and soil properties. A project was initiated at MSFC in FY 90 under the Center's Directorate Discretionary Fund (CDDF) to study small-scale effects of vegetation on the distribution and fluxes of soil moisture. Installation of a large array of instruments was accomplished during that first year (FY 90), during this second year of the project the instrumentation and data collection systems were improved and data has begun to be taken. Preliminary analysis of the data show that the equipment has been functioning properly. This report presents some of the preliminary results that have recently been analyzed.

Introduction

The Mission to Planet Earth has as one of its main objectives the study of the changes that the planet has and is undergoing. Mission to Planet Earth describes a focused effort in satellite remote sensing and the associated ground-based research from a variety of fields that will characterize the global environment as an interacting system. The Earth Observing System (EOS) is an integral part of Mission to Planet Earth and is dedicated to providing the new observations, data and information necessary to understand the way the Earth works as a natural system.

With the development of EOS, scientists will be able to observe and understand many of the key variables and processes of the global-scale cycles of energy and water. Water plays a global role of enormous variety of Earth system processes. Water is considered to be the most powerful agent of topographic change. Water is also necessary for life on Earth, playing a major role in climate regulation. In addition to its role in ocean circulation and precipitation, water can also affect climate in the continents through transpiration within plant and soil ecosystems. Short term hydrological events, such as droughts or large precipitation activity can cause substantial ecological changes on regional scales.

The ability to model the current climate and potential climate changes is intimately connected to our understanding of the hydrologic cycle. The generalized schemes that are used in models are unlikely to be equally applicable to all

areas, which means that the ability to simulate climate and climate changes will vary from area to area. It is necessary to include in models all the characteristics of a particular area which may impact these processes. One of the chief characteristics that varies from area to area and impacts hydrologic processes is the vegetation.

Large scale hydrologic studies are essential to the NASA/MSFC EOS initiative in order to better understand hydrological flux processes that are a main ingredient in global biosphere interactions. One of the most important questions for modeling the global hydrologic cycle includes the interrelationship between land surface and atmospheric processes for variable spatial and temporal scales. Global climate models have shown that proper modeling of the Earth's surface (which is commonly modeled as a boundary layer) is of great importance to the results obtained in such modeling studies.

Scope of Work

During the summer of 1990 a large array of soil moisture and precipitation instruments were installed at a field site within Redstone Arsenal to monitor the ambient atmospheric and soil conditions. Tipping bucket rain gauges monitor sub-canopy throughfall and stemflow and free-field precipitation. In addition an array of 36 manually-read rain gauges has been installed, this year, beneath the tree canopy in a six-by-six grid to evaluate the spatial variability of soil moisture that can be attributed to throughfall. Thirty three sets of tensiometers were also installed in various locations. Each set having three tensiometers installed at 1', 2', and 3' depths. The tensiometers are used to monitor the soil moisture conditions prior to, during, and after rain events. Data acquisition for the system is controlled by three programmable data loggers that sample the instruments at specified times and upload the information to solid state storage modules that are subsequently downloaded to a PC for analysis.

Preliminary results show that the instrumentation is generating good data. These results have enabled us to begin to make comparisons between the soil-vegetation conditions at the site (i.e. bare, grass-covered, and grass and tree-covered soil). Comparisons can also be made of the canopy-covered to the free-field areas. Data from the tipping bucket and manually read rain gauges have shown temporal and volumetric variations in the amounts of precipitation reaching the ground. However a statistically valid data base must be developed in order to make definite conclusions. The soil moisture response to precipitation events is shown in Figure 1 in the form of tensiometer signals at depths of 1'

and 3' with precipitation amounts in time. Figure 1 shows that the response of the tensiometers prior to a precipitation event is in the form of drying (i.e. increase in tension) while after the precipitation the tension begins to diminish. One can also notice that the response of the 1' depth tensiometers is quite dramatic and quick while for the 3' depth tensiometers it is greatly attenuated in quantity and response time.

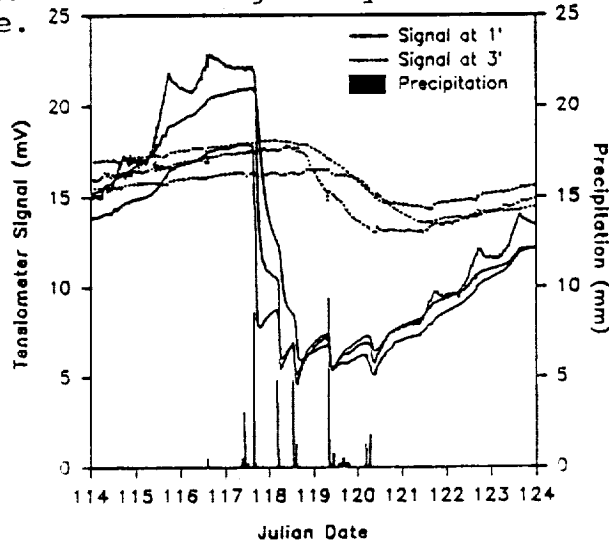


Figure 1.- Soil moisture response to precipitation events over a ten day period as a function of depth.

Figure 2 presents the response of the tensiometers after a precipitation event. This figure shows that a higher rate of moisture loss is observed for the upper most soil layers. A higher moisture loss is also observed for soils with both trees and grass cover, as compared to that of grass cover or bare soil. This last point illustrates the importance of the study of the effects of vegetation on soil moisture conditions.

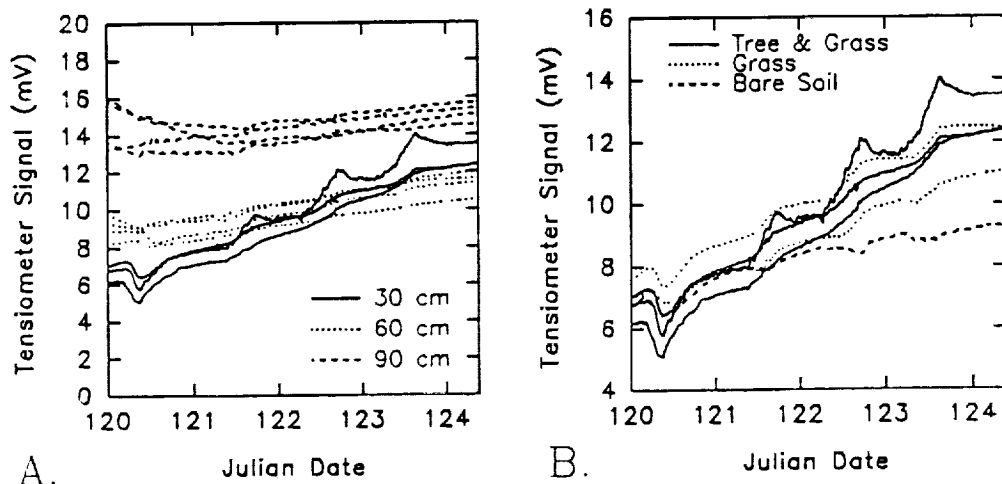


Figure 2. Rate of soil moisture loss as a function of (A) depth, and (B) vegetation cover.

Acknowledgements

The author would like to thank his NASA/MSFC colleague, Dr. N. C. Costes, ES-42 for the opportunity to conduct this research. Thanks are also due for his associate, Dr. Charles A. Laymon USRA/ES-42, for his many useful suggestions and his major improvements to the instrumentations systems during this second year of work. Finally, the author would like to thank Dr. Frank Six of the University Affairs Office and his secretary Ms. Billie Swinford and Dr. Gerald Karr of The University of Alabama in Huntsville and his secretary Ms. Christine Troutman for all of their enthusiasm and help during this summer period.

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